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मानक

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Mazdoor Kisan Shakti Sangathan

“The Right to Information, The Right to Live”

“पुराने को छोड़ नये के तरफ”

Jawaharlal Nehru

“Step Out From the Old to the New”

IS 12393 (1988): Electroplated coatings of nickel [MTD 7: Light Metals and their Alloys]



“ज्ञान से एक नये भारत का निर्माण”

Satyanarayan Gangaram Pitroda

“Invent a New India Using Knowledge”



“ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है”

Bhartrhari—Nitiśatakam

“Knowledge is such a treasure which cannot be stolen”

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Indian Standard

SPECIFICATION FOR
ELECTROPLATED COATINGS OF NICKEL

1. Scope — Covers nickel electrodeposited coatings that are applied to iron or steel, zinc alloys, copper or copper alloys, and aluminium and aluminium alloys to provide an attractive appearance and corrosion resistance. Several classes of coatings are provided that differ in thickness. The selection of coating class depends upon the service grade to which the coated product may be exposed.

1.2 The minimum thickness requirements apply to those portions of the significant surface that can be touched by a ball 20 mm in diameter. All other requirements must be satisfied on the whole of the significant surface defined in 2.

1.3 This standard does not cover coatings applied:

- a) for purposes other than protective and decorative;
- b) to machine screw threads;
- c) to surface condition that the basis metal is to have prior to the coating process; and
- d) to mill products like sheet, strip or wire in the unfabricated form or coil springs.

*Reference Copy-BIS-SCIE-STEP
Standards Information Centre, Mysore*

2. Significant Surface — For the purpose of this standard, significant surface is defined as the part of the article covered or to be covered by the coating and for which the coating is essential for serviceability and/or appearance, by a specified thickness of nickel.

2.1 When necessary, the significant surface shall be the subject of agreement and shall be indicated on drawings or by the provision of suitably marked sample.

3. Information to be Given with an Enquiry and Order — Information to be supplied while ordering plating of articles in accordance with this standard, purchaser should furnish the informations given in Appendix A.

4. Classification for Coatings

4.1 Service Grade Number — The service grade number is used by the purchaser to specify the degree of protection required, as related to the severity of the conditions to which a product is to be subjected, in accordance with the following scale:

- a) 3 — Severe,
- b) 2 — Moderate,
- c) 1 — Mild, and
- d) 0 — Exceptionally mild.

4.2 Coating Classification Number — The coating classification number comprises the following:

- a) The chemical symbol for the basis metal (or for the principal metal or an alloy) followed by a slash as follows:
 - 1) Fe/for iron or steel,
 - 2) Zn/for zinc or zinc alloys,
 - 3) Cu/for copper or copper alloys, and
 - 4) Al/for aluminium or aluminium alloys;
- b) The chemical symbol for copper (Cu), if copper or brass containing greater than 50 percent copper is used as an intermediate coating;
- c) A number indicating the minimum thickness of the copper coatings, in micrometres;

- d) The chemical symbol for nickel (Ni);
- e) A number indicating the minimum thickness of the nickel coating, in micrometres; and
- f) A letter designating the type of nickel coating (see 6.2.2.2).

4.2.1 Example of a complete classification number — A coating on steel comprising 20 µm copper (minimum) plus 30 µm bright nickel (minimum) has the classification number:

Fe/Cu20 Ni 30 b

4.3 Coatings Appropriate to Each Service Grade Number — Tables 1 to 4 show, for the various basis metals, the coating classification numbers appropriate for each service grade number.

TABLE 1 NICKEL COATINGS ON STEEL (OR IRON)
(Clauses 4.3, 6.2 and 6.2.1)

Service Grade Number	Classification Number*
3	Fe/Ni30b
2	Fe/Ni20b
1	Fe/Ni10b
0	Fe/Ni 5b

Note — A copper undercoat may be used. If the minimum thickness of copper is 20 µm, then for service grade number 3, the minimum thickness of nickel may be reduced by 5 µm below the value stated in the table. When a copper underlayer is used for service grade numbers 0, 1 and 2, on reduction in minimum nickel thickness shall be made.

*s-nickel may be substituted for b-nickel in each classification number. p- or d-nickel may be substituted for b-nickel in service grade numbers 3, 2 and 1.

TABLE 2 NICKEL COATINGS ON ZINC ALLOYS
(Clauses 4.3, 6.2 and 6.2.1)

Service Grade Number	Classification Number*
3	Zn/Cu Ni35b
2	Zn/Cu Ni15b
1	Zn/Cu Ni 7b
0	Zn/Cu Ni 5b

Note — All the nickel coatings shall be applied over an undercoat of copper or brass (with at least 50 percent copper) deposited from a cyanide electrolyte having a minimum thickness of 8 µm. If the minimum thickness of copper is increased to 15 µm by subsequent deposition from a bright acid copper bath, then for service grade number 3, the minimum thickness of nickel may be reduced by 5 µm below the value stated in the table. No reduction in the minimum thickness of nickel shall be made for other service grade when additional copper is used.

*s-nickel may be substituted for b-nickel in each classification number. p- or d-nickel may be substituted for b-nickel in service grade numbers 3 and 2.

TABLE 3 NICKEL COATINGS ON COPPER AND COPPER ALLOY
(Clauses 4.3, 6.2 and 6.2.1)

Service Grade Number	Classification Number*
3	Cu/Ni20b
2	Cu/Ni10b
1	Cu/Ni 5b
0	Cu/Ni 5b

*s-nickel may be substituted for b-nickel for each service grade. p- or d-nickel may be substituted for b-nickel in service grade numbers 3 and 2.

TABLE 4 NICKEL COATINGS ON ALUMINIUM AND ALUMINIUM ALLOYS

(Clauses 4.3, 6.2 and 6.2.1)

Service Grade Number	Classification Number*
3	A1/Ni30b
2	A1/Ni20b
1	A1/Ni10b

Note — A copper undercoat may be used, but the minimum thickness of nickel shall be that stated in the table.

*p-, d- or s-nickel may be substituted for b-nickel for each service grade number.

5. Heat Treatment of Steel — When required by the purchaser, heat treatment as described below shall be performed on certain steels to reduce the risk of damage by hydrogen embrittlement.

5.1 Stress Relief Before Electroplating

5.1.1 Severely cold-worked steel parts — Severely cold-worked steel parts, or parts made from steel of tensile strength 1 000 MPa (or corresponding hardness*) or greater, that have been ground or subjected to severe machining after tempering, shall normally be stress-relieved. As a guide, the parts may be maintained for 30 minutes, preferably at the highest temperature which may be applied without adversely affecting their strengths. For example, for heat treated steels, at temperatures not exceeding the tempering temperatures. For parts made from certain types of steel, a temperature of 190 to 210°C for not less than 1 h may be adequate.

5.1.2 Heat treated steels — Some steels that have been carburized, flamehardened or induction-hardened and subsequently ground would be impaired by the treatment given in 5.1.1, and shall instead be stress relieved at a lower temperature and for a longer period of time, for example, at 170°C for greater than 1 h.

5.2 Heat Treatment After Electroplating

5.2.1 Components subject to stress or made from higher tensile strength — Components that are subject to fatigue or sustained loading stresses in service and made from severely cold-worked steels or from steels of tensile strength 1 000 MPa (or corresponding hardness) or greater, shall be heat treated after the coating is applied. Guidance is given in Table 5.

TABLE 5 GUIDANCE ON HEAT TREATMENT OF STEEL PARTS AFTER PLATING

Tensile Strength MPa	Maximum Sectional Thickness of Part mm	Minimum Period at 190 to 210°C hours
1 000 to 1 150	Less than 12	2
	12 to 25	4
	Over 25	8
1 150 to 1 400	Less than 12	4
	12 to 25	12
	25 to 40	24
		Heating to commence within 16 h of plating
	Over 40	Requires experimental determination

5.2.2 Surface hardened components — Where the heat treatment temperatures would be harmful, as for example, to certain surface-hardened articles, it may be necessary to apply a lower temperature for a longer time.

6. Coating Requirements

6.1 Finish and Appearance — Over the significant surface, the coating shall be free from clearly visible plating defects, such as blisters, pits, roughness, cracks unplated areas, stains and discolourations. The

*30 HRC, 295 HV, 280 HB (approximate values).

extent to which defects may occur on non-significant surfaces shall be specified by the purchaser. Where rack marks are unavoidable, their position on the surface shall be specified by the purchaser.

6.2 Thickness and Type of Coatings — The thickness and type of coatings shall correspond to the classification numbers given in Tables 1 to 4 for the specified service grade number. The minimum allowable thickness for the metal coating shall be required on any points on the significant surface that can be touched by a ball 20 mm in diameter, unless the purchaser specifies that other points shall also meet those thickness requirements. For tests prescribed to determine coating thickness, see 8.1.

6.2.1 Thickness of copper coating — In copper plus nickel coatings, the minimum thickness for copper is indicated in the notes in Tables 1 to 4.

6.2.2 Thickness and type of nickel coatings

6.2.2.1 Thickness of nickel coatings — The total minimum thickness of nickel coatings shall be that designated by the classification number (see 4.2).

6.2.2.2 Type of nickel coatings — The type of nickel shall be designated by the following symbols:

- a) *b* for nickel deposited in the fully bright condition;
- b) *p* for dull or semi-bright nickel which has been polished;
- c) *s* for dull, satin or semi-bright nickel which shall not have been mechanically polished; and
- d) *d* for double or triple layer coatings which shall have the properties given in Table 6, and passed the ductility test given in Appendix B.

TABLE 6 PROPERTIES OF DOUBLE AND TRIPLE LAYER NICKEL COATINGS

(Clauses 6.2.2.2 and 8.4)

Layer (Type of Nickel)	Specific Elongation, Percent	Sulphur Content Percent	Thickness Percent Relative to Total Nickel Thickness	
			Double Layer	Triple Layer
Bottom (s)	> 8	≤ 0.005	≥ 60	≥ 50
Middle (high sulphur <i>b</i>)	—	Greater than 0.15 mass percent	—	10 Max
Top (<i>b</i>)	—	> 0.04 and ≤ 0.15	≤ 40	≤ 40
Test Method	See Appendix B and Note 1			

Note 1 — The sulphur contents are specified in order to indicate the type of nickel plating solution that is to be used. No simple method exists for determining the sulphur content of a nickel deposit on a coated article. An accurate determination is possible on a specially prepared test specimen by the methods given in draft Indian Standard for the method of determination of sulphur in electrodeposited nickel (*under preparation*).

Note 2 — It will usually be possible to identify the type and thickness of nickel layers by microscopical examination of a polished and etched section of an article prepared according to IS : 3203-1982 'Methods of testing local thickness of electroplated coatings (*first revision*)'.

6.3 Adhesion — The coating shall be sufficiently adherent to the basis metal, and the separate layers of a multilayer coating shall be sufficiently adherent to each other, to pass the test prescribed in 8.2.

6.4 Corrosion Resistance — Coated articles shall be sufficiently corrosion resistant and pore free to pass the test prescribed in 8.3 for the individual service condition number. The performance rating shall be determined according to IS : 6009-1970 'Method for evaluation of results of accelerated corrosion tests'. The minimum acceptance rating shall be 8 after the test described in 8.3.

7. Sampling — Out of each lot of similar parts, a number of samples shall be selected at random. The size of the lot and the number of samples to be selected shall be agreed upon by the manufacturer and the purchaser. All the samples selected shall be visually examined for any defects referred to in 6.1.

8. Methods of Test

8.1 Thickness — The thickness of a coating and its various layers shall be measured at any point on the significant surface that can be touched by a ball 20 mm in diameter. The microscopical

method described in IS : 3203-1982 'Method of testing local thickness of electroplated coatings (*first revision*)' may be used to measure the thickness of each nickel layer when it is 10 μm or more, and of a copper undercoat.

8.1.1 The magnetic method described in IS : 3203-1982 may be used to measure the total thickness of *b*, *d*, *s*, or *p* nickel on zinc alloys and copper alloys, if an appropriate calibration can be made.

8.1.2 Other methods may be used if it can be demonstrated that the uncertainty of the measurement is less than 10 percent.

8.2 Adhesion — Adhesion of the coating shall be tested by either the file test or the quenching methods given in Appendices C and D. There shall not be any detachment of the coating from the substrate or any separation between layers of the coating.

8.3 Corrosion Resistance — Nickel coating without chromium top coats are not widely used and, as a result, there is limited information about their performance in accelerated tests and in actual service.

8.3.1 Coated articles shall be subjected to one of the corrosion tests given in Table 7 for the particular service grade number. The particular test to be specified by the purchaser. The duration of each corrosion test has not been established experimentally and the times suggested in Table 7 are provided as guidance. In order to assure that the coatings render a useful service, the duration of the corrosion test shall be approved by the purchaser taking into account the requirements of the particular application and its intended service.

TABLE 7 GUIDANCE ON CORROSION TESTING ON NICKEL COATINGS

Basis Metal	Service Condition Number	Duration (in Hours) of Corrosion Test*	
		CASS (See IS : 5528-1985)	Acetic Salt (See IS : 6910-1985)
Steel (or Iron)	3	16	96
Zinc and zinc alloys	2	8	24
Copper and copper alloys	1	4	8
Aluminium and aluminium alloys	0	†	†

*The duration of each corrosion test has not been established experimentally and the times indicated are provided as a guidance only.

†To be specified by the purchaser.

8.3.2 The corrosion tests described in IS : 5528-1985 'Method of testing corrosion resistance of electroplated and anodized aluminium coatings by copper-accelerated acetic acid salt spray (CASS) test (*first revision*)' and IS : 6910-1985 'Methods of testing corrosion resistance of electroplated and anodic aluminium coatings by acetic acid saltspray test (*first revision*)' are useful in controlling the continuity and quality of the coating, but the duration bears little relationship to the service life of the finished article, especially in connection with the nickel coating covered in this standard.

8.3.3 After the articles have been subjected to the appropriate corrosion test, they shall be examined and rated according to IS : 6009-1970 'Method for evaluation of results of accelerated corrosion tests' (see 6.4).

8.4 Ductility — The ductility shall be such that the elongation will not be less than stated in Table 6 for nickel when tested by the method given in Appendix B. Greater elongation may be requested, but shall be subject to agreement between the purchaser and the manufacturer.

9. Marking — The marking related to the coating shall include service grade and classification numbers as specified in this standard and the name or trade-mark of the manufacturer.

9.1 Certification Marking — Details available with the Bureau of Indian Standards.

APPENDIX A

(Clause 3)

INFORMATION TO BE GIVEN WITH AN ENQUIRY OR ORDER

A-1. Mandatory Information

A-1.1 When ordering articles to be electroplated in accordance with this standard, the purchaser shall provide the following information:

- The number of this standard.

- b) The basis metal and the service grade number denoting the severity of the conditions it is required to withstand (see 4.1).

or

The classification number of the particular coating required (see 4.2). If the basis metal and the service grade number are quoted and not the classification number, the electroplater is free to supply any of the classes of coating corresponding to the service grade number, but he shall inform the purchaser of the classification number of the coating, when requested.

- c) The appearance required, for example, bright, dull, or satin. Alternatively, samples showing the required finish or range of finish shall be supplied or approved by the purchaser.
- d) The corrosion test to be used, if any, shall be specified by the purchaser.
- e) The adhesion test to be used, if any, shall be specified by the purchaser.
- f) The extent to which defects shall be tolerated on non-significant surfaces shall be specified by the purchaser.
- g) The significant surfaces shall be specified by the purchaser and indicated on drawings of the parts or by the provision of suitably marked specimens.
- h) When it is impossible to avoid rack or contact marks on significant surfaces, the position of those marks shall be approved by the purchaser.
- j) Sampling methods and acceptance levels shall be specified by the purchaser.

A-2. Additional Information

A-2.1 The following additional information may be provided by the purchaser, when appropriate:

- a) The tensile strength of the steel and the need for heat-treatment, either before or after electroplating.
- b) In those cases, where thickness coatings than are covered by this standard are required, the particular thickness desired shall be specified by the purchaser.
- c) The purchaser may specify thickness requirements on those points that cannot be touched by a ball 20 mm in diameter.

APPENDIX B

[Clause 6.2.2.2(d)]

DUCTILITY TEST

B-1. Preparation of Test Piece

B-1.1 Prepare a coated test strip 150 mm long, 10 mm wide and 1 ± 0.1 mm thick by the following method:

Polish a sheet of the appropriate basis metal, similar to that of the articles being coated except that the sheet may be of soft brass if the basis metal is zinc alloy. Use a sheet that is sufficiently large to allow the test strip to be cut from it after trimming off a border at least 25 mm wide all round. Electroplate the polished side of the sheet with nickel to a thickness of 25 μ m under the same conditions and in the same bath as used with the corresponding articles.

Cut the test strip from the coated sheet with a guillotine or flat shear. Round or chamfer the longer edges of the test strip at least on the plated side by careful filing or grinding.

B-2. Procedure — Bend the test strip with the coated side in tension, by steadily applied pressure, through 180° over a mandrel of diameter 11.5 ± 0.1 mm, until the two ends of the test strip are parallel. Ensure that contact between the test strip and the mandrel is maintained during bending.

B-3. Assessment

B-3.1 The coating is deemed to comply with the minimum requirement of an elongation of 8 percent provided that, after testing, there are no cracks passing completely across the convex surface. Small cracks at the edges do not signify failure.

B-3.2 This test is used to check that the type of nickel deposit complies with the coating requirements given in 6.2.2.2 (see also 8.4).

APPENDIX C

(Clause 8.2)

FILE TEST FOR ADHESION

C-1. Procedure — Cut a piece of plated article, hold it in a vice and apply a coarse file to the cut edge in such a manner as to try to raise the deposit. File in the direction from the basis metal to the coating at an angle of approximately 45° to the coated surface. There shall be no separation between the coating and the basis metal.

APPENDIX D

(Clause 8.2)

QUENCHING TEST FOR ADHESION

D-1. Procedure — Heat plated article for 1 h in an oven at a temperature of 250°C with a tolerance of $\pm 10^\circ\text{C}$. Then quench in room temperature water. The appearance of blisters or peeling shall give evidence of inadequate adhesion.

Caution — This test may have an adverse effect on the mechanical properties of the article tested.

EXPLANATORY NOTE

The nickel coatings without chromium top coats that are covered by this standard are suitable for applications in which tarnishing is prevented by rubbing or handling in service or by the use of top coats other than chromium. They are also suitable for those applications where tarnishing is of no importance. Similar coatings that provide an attractive appearance and corrosion resistance, and that do not tarnish in service are covered by IS : 1068-1985 'Specification for electroplated coatings of nickel and chromium on iron and steel (first revision)'. IS : 4827-1983 'Specification for electroplated coatings of nickel and chromium on copper and copper alloys' and IS : 4828-1983 'Specification for electroplated coatings on nickel and chromium on zinc and zinc alloys'.

In the preparation of this standard, considerable assistance has been taken from ISO/OIS 1458 'Metallic coatings — electrodeposited coatings of nickel', issued by the International Organization for Standardization (ISO).